BAKING TEST AS COMMERCIALLY APPLIED TO WHEAT & FLOUR

BY

P. G. PIRRIE

ARMOUR INSTITUTE OF TECHNOLOGY

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PETER GUSTAVE PIRRIE

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Approved: - Harry McCormack
Professor of Chemical Engineering

Approved : - H. M. Raymond
Dean of Engineering Subjects

L. C. Monin,
Dean of Cultural Studies.

I N D E X

SOME OBSERVATIONS ON THE BAKING TEST AS COMMERCIALLY APPLIED TO WHEAT AND FLOUR

The testing of different varieties of wheat and flour and of different lots of the same variety for relative baking value, is a line of experimental work that is becoming more and more recognized as a commercial necessity.

The grading of wheat by a man who grades simply by feel, taste, and appearance is yielding to grading by a chemist who has performed a milling and baking test upon the sample.

The general idea of the system is first to mill the wheat sample to flour, then to analyze the flour and bake it under identical conditions with a standard flour. In this way the sample can be judged in terms of the standard flour of the locality. Such a comparison would be very valuable if it were not that the methods of milling and the various systems of baking used by the different commercial laboratories are so varied that it is difficult to place a comparative value on reports of wheats or flours tested in different laboratories.

It has been the good fortune of the writer to be placed in charge of a most excellent equipment designed

for carrying out the milling and baking tests on wheat and flour. One of my first experiences was to have returned to me a report of another laboratory on a sample of wheat I had tested, which report was attached to one of mine on the same sample, with hardly an agreeing figure. Therefore, for some six months it has been my aim to discover the reasons for these wide differences in reports on the same sample from different laboratories, and also, if possible, to discover a method of performing such tests that would be logical and representative enough to be suggested for use as standard.

With the idea of determining the points in which the disagreement is most evident, a set of samples was made up and sent to two commercial laboratories considered by the trade to be the best in the country. These samples were milled and baked by myself according to prevailing government methods, and the results were compared to those reported by the two laboratories.

The United States Government laboratories have no bulletin on baking and milling tests, but the Kansas State Agricultural College Experiment Station Bulletin No. 117 describes the tests essentially as the Govern-

ment laboratories carry them out. Hence the method of this bulletin was followed.

The varieties sent out were a Northern Spring wheat and a Kansas 2 Hard. A tabulated comparison of the reports follows:-

WHEAT	Northern Spring			Kansas 2 Hard		
	Home	A	B	Home	A	B
Protein	14.4	13.6	13.0	11.5	11.6	11.4
Ash	1.79	1.70	1.78	2.01	1.8	1.8
Moisture	13.1	12.7	13.65	10.5	11.8	11.4
MILLING TEST						
Weight Scoured	1250	2100	1250	1250	2100	1250
Loss on Scouring	32	36	25	40	34	15
Weight Milled	1000	2000	1000	1000	2000	1000
Passes on Rough Rolls	9		3	9		3
Passes on Smooth Rolls	8		12	8		10
Weight of Bran	272	165	300	243	105	260
Weight of Shorts	27	280	55	25	290	70
Weight of Flour	660	1390	645	715	1440	670
Loss in Mill	41	165	0	127	165	0
FLOUR						
Protein	12.7	11.5	12.4	10.1	9.3	9.7
Ash	.54	.47	.47	.50	.55	.46
Moisture	12.54	12.7	13.0	12.1	11.7	12.3
BAKING TEST						
Absorbtion, per cent.	59.0	54.7	60.0	59.0	56.2	59.0
Time Max, Expansion, Min.	171	315	120	192	302	120
Volume in cu. in.	76	205	110	74	183	105
Weight flour per loaf, grams	340	340	350	340	340	350
Weight of loaf, grams	498	490	600	498	490	590

It is very evident from the foregoing that each laboratory had a method of milling and baking of its own. What similarity there is is very slight.

When we consider the results of baking, we see that my system and that of "B" are somewhat similar but do not agree in results, and that "A" bakes in such a way as to get almost three times our volume of loaf.

It cannot be expected that any subsequent determination will check when the methods of milling differ so widely. This is made very evident from an examination of the results of the chemical tests and the absorbtion. The fact, however, that this difference may be wholly explained by the difference in the method of milling and baking, and that the flours were really not chemically as different as the tests indicate, led me to put up five sets of flour, of five samples each, and send them out to several different laboratories to check up the chemical part of the work.

The report follows:-

PROTEIN, as reported

		Home	"B"	"C"	"D"	"E"
Sample No.	"L"	11.60	11.30	11.96	11.62	11.37
	"M"	10.05	9.90	10.20	10.08	10.82
	"N"	9.50	8.95	9.75	9.87	10.32
	"O"	9.05	8.95	9.30	9.30	9.82
	"P"	10.70	10.0	11.11	10.89	10.85

Careful observation of these analyses will show that if we take the average of "C" and "D" reports (these two laboratories are admitted by everyone to be unquestionable in this particular analysis) and compare this average with my report, they check in every case as closely as is possible in an ordinary Kjeldahl determination. However, both "B" and "E" differ as much as one whole per cent.

This shows that careless work is being done by just those laboratories that do not check the baking tests under discussion. It is astonishing that a laboratory of nation-wide reputation such as "B" enjoys would report samples "N" and "O" the same in protein when four other laboratories agree that there is 50% difference in favor of "N".

Having thus shown to my satisfaction that the disagreement in chemical data is due more to careless analysis than to actual difference in sample, it remained to check up these laboratories on the baking results. This was done by sending them a sample of wheat to be tested, and somo weeks later sending, thru a different channel, a sample of the same wheat to the same laboratory.

On comparing the two reports it was found that the chemical data did not check, but that the baking data did, at least as closely as it is reasonable to expect. This means that, whatever the disagreement in chemical data is due to, it is fairly certain that the disagreement in baking data is due chiefly to the difference in milling and baking systems of different laboratories, each laboratory having a milling and baking system of its own. This is brought out very forcibly when it is remembered that laboratories will persistently check themselves but not each other.

It remains therefore to discuss the various methods of conducting milling and baking tests, and, if possible, to determine methods that bring out to the best advantage the relative qualities of the samples under consideration. The equipment used for this work is briefly described, and the methods finally adopted are outlined in the following pages.

Method of Performing

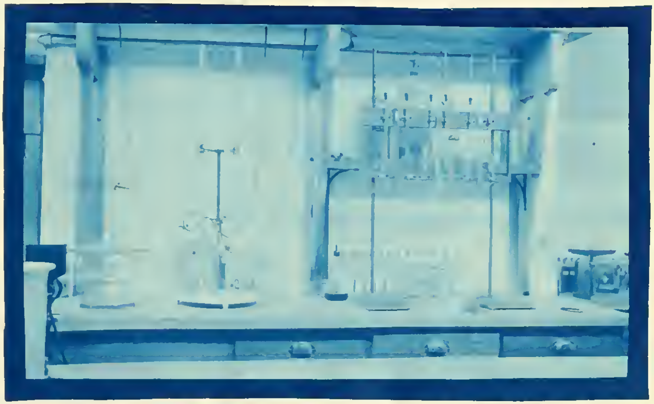
Strictly Chemical and Physical Tests

The chemical work was done along standard lines as indicated by Bulletin No. 107 of the United States Department of Agriculture. These methods are beyond all doubt as efficient as can be devised, and no changes were made except those needed to meet local conditions. Such details as are not covered by Bulletin No. 107 are given below.

All flour samples were weighed by difference from glass weighing bottles, using aluminum spoons which were left inside the weighing bottle during all operations.

Moisture determinations on flour were made in glass tubes 3-4 in. x 3 in., heating in air at 103° C. for seven hours and weighing in a glass capsule to avoid the effect of the absorbtion of moisture by the hygroscopic material.

Moisture tests on wheat were made by the use of the Brown and Duvel Moisture Tester as finally adopted by the Department of Agriculture. This consists essentially of a set of stills heated by gas, in which 100

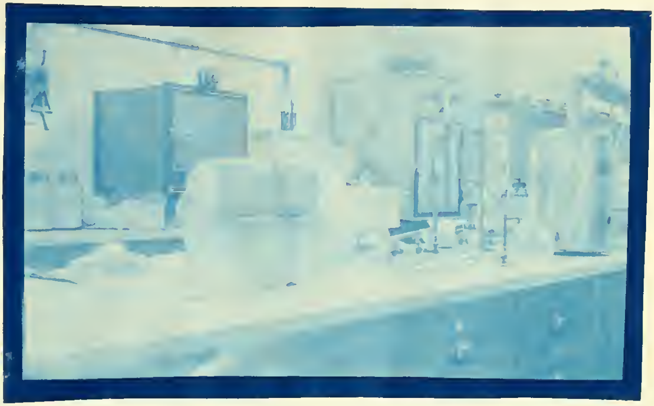


Laboratory Equipment

grams of wheat is placed and covered by a non-volatile oil. On being heated, the moisture is distilled off and collected in a graduate. The volume in c.c. gives the percentage directly. This apparatus was operated according to the directions furnished by the Kny Sheerer Co., of New York.

Specific gravity of the wheat kernel was determined according to the method of Circular No. 99, United States Department of Agriculture, Bureau of Plant Industry. This consists essentially in placing a weighed quantity of the cereal in a picnometer or specific gravity bottle and then filling the bottle up to the mark with toluene. The specific gravity of the toluene being known, and its weight determined by difference, the volume of the cereal can be obtained and the specific gravity calculated.

The "weight of 100 kernels" was determined by folding a paper to form a V-shaped gutter and then pouring in a handful of the wheat from one end of the gutter. By commencing at one end and counting off 100 kernels, a very average sample can be obtained. Two sets of 100 kernels are weighed to one milligram and the average taken.



Laboratory Equipment

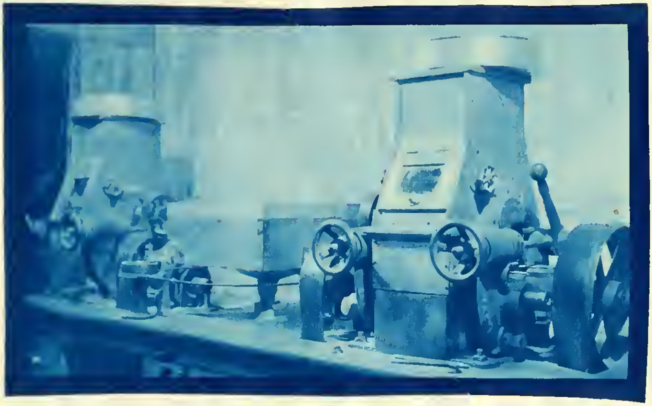
When it was necessary to report weight per bushel, a 500 c.c. glass graduate was filled level full with the sample, and the weight of this volume of wheat in grams multiplied by .16 to give the weight of one bushel in pounds. The factor .16 is derived from the fact that one bushel of water weighs 80#. Therefore,

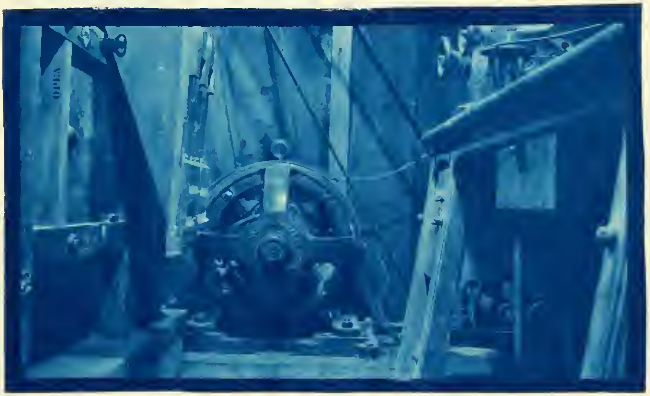
$$\frac{80 \times \text{weight wheat in grams}}{\text{weight water in grams}} = \text{weight of wheat in pounds per bu.}$$

Apparatus for Milling and Baking

Before taking up the discussion of the methods of milling and baking, a short description of the apparatus should be of value.

The wheat was milled on a special Allis Chalmers Experimental Mill comprising three sets of six-inch rolls and a jig bolting machine. Two sets of the rolls were corrugated; one set 16 and 12 to the inch and the other 24 and 18 to the inch. These rolls grind dull to sharp and the fast roll runs a little more than twice as fast as the slow one. The smooth rolls have a differential of 7 to 10, that is, the fast roll makes 10 revolutions while the slow one makes 7. Accurate adjustment of the rolls is provided by two large screws on the side of each roll, which allow the rolls to be adjusted so that they are in the same plane, and by two smaller screws to set them parallel. The rolls are thrown "in" and "out" by means of a lever. A mechanical jig bolting machine completes the equipment of the mill. Frames of standard bolting cloths are made to fit this jig; and as many as four frames may be inserted at one time.





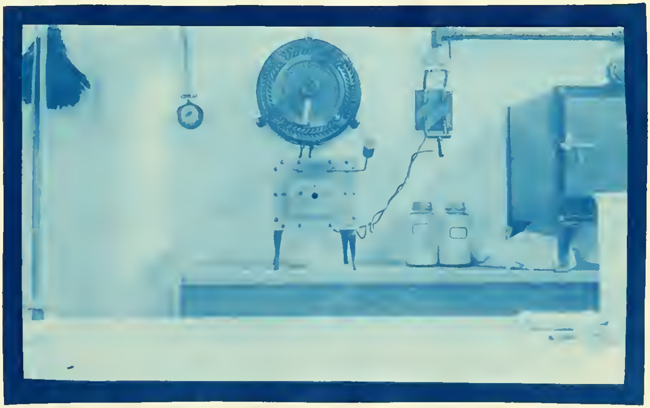
Milling Apparatus

Before going to the mill the wheat must be clean, as that term is ordinarily understood. This is usually accomplished by the use of some sort of fanning mill, which does not, however, remove much dirt from the crease. In these experiments a Eureka Horizontal Close Scourer, manufactured by the S. Howes Co. was used. It removes the crease dirt, a considerable portion of the outer bran coat, and the beard from the end of the kernel. The Scourer is capable of wide adjustment to suit various sizes of stock.

The complete scouring and milling equipment is run by a five horse power electric motor connected thru clutches so that either or both machines may be run at one time.

The baking of the flour was performed by the use of a 35° C. electric-heated special dough raising cabinet and a Simplex Electric Oven with a range of from 150° C. to 325° C.

The pans used for baking were identical with those used by the United States Government laboratories and of the following inside dimensions:- Bottom, 2 7-8 in. x 5 13-16 in. Top, 3 7-16 in. x 6 13-16 in. Depth, 5 7-16 in. They are designed to use 340 grams (12 oz.) of flour and yield a loaf of about 500 grams (17 1-2 oz.)



Ovens

and 1750 c.c. (or 105 cu. in.).

Besides the above equipment there is a full chemical outfit, including a constant temperature Freas Electric Oven with a range of from room temperature to 185° C., which is used for the moisture tests on the flour, and a Hoskins Electric Muffle with a range of from 250° C. to 1100° C. (145° F. to 2000° F.) for running ashes.

Explanation of

System of Testing

As before stated, the principle of the system is to mill the wheat sample to flour and then analyze and bake the flour under identical conditions with the standard flour of the locality. In the case of flour samples, the process is, of course, the same with the omission of the milling operation.

The question of the standard is a very perplexing one, as it is not fixed but depends largely on the local requirements. That which is considered the best flour in one district is not the best in another, and therefore the chemist first requires to know the exact kind of flour the miller wishes to make. The miller can usually lay his hands on one particular parcel which has the approval of his most skillful and critical customers, which he would like always to supply and which he would be content to take as standard. If he can also obtain certain samples which more or less fall short of this standard, and with clearly marked defects, they will also be of service. The chemist should be supplied with these samples, and his first object should be to find out

where the faulty samples differ from the standard one. There can be given no general directions as to how this is to be done, since it is here that the skill and judgment of the expert are brought to bear on the problems of each particular flour. However, a baking test will usually yield very definite information, and it is almost wholly upon data from such tests that the grading of samples depends. Still it is remarkable how soon, as a result of regular testing, the chemist can form an opinion on the quality of flour and recognize deviations from the standard by observation of purely empirical factors.

Having such a standard, the matter of testing the samples on hand takes a rather definite form. If the idea is to sell wheat to the mill, then the samples on hand will be milled and baked alongside the standard. The selling points of the wheats on hand can then be very clearly brought out, and the mill will know exactly what it is buying. It is of course usual that tests will be made by both parties to the sale, and the reports of the two laboratories will be checked against each other.

If the function of the laboratory is to control the running of the mill itself, the miller will take samples from those parts of the mill which will afford the most information, and the chemist will duly test the same. In particular if suspicion attaches to the work of any one machine or part of the mill, samples of the products of this section will receive special attention. If any marked departure from the usual standard occurs, attention should be drawn to it, and the defect remedied by proper adjustment.

It is almost entirely with the former object, that of selling wheat to the mills, that the present investigation was undertaken, and the present discussion is an attempt at a solution of the cause for the wide differences that exist in reports on the same samples from different laboratories. These differences are especially pertinent when the two laboratories are those of buyer and seller, and a referee chemist appointed to clear the trouble furnishes a third report that differs as widely from either of the other two as they differ from each other.

It is accepted almost without question that chemical tests alone furnish little or no reliable informa-

tion as to milling qualities of wheat and subsequent baking qualities of the flour produced. While much excellent work has been done along these lines, no chemical or physical factors have as yet been discovered which will furnish the required information. It seems that at present the only means for judging the bread-making capacity of a wheat or flour is an actual baking test.

Therefore, under the circumstances, the only true test for wheats is the milling test, in which the various wheats are ground separately, and their resultant flours tested chemically and by baking. In the following pages a discussion of the various methods used for these tests is taken up and a system outlined which is thought sufficiently representative of actual conditions as to be used as standard.

Discussion of Methods of Milling

It has already been stated that the best general mode of testing wheats at present is that of first reducing the grain to flour and then testing the flour. With this end in view the larger mills are frequently fitted with small reduction plants by which an experimental quantity of wheat may be reduced to flour and this tested before the whole of the wheat is ground. The plant for this purpose may be of various sizes from a fairly complete small roller mill installation to a specially made machine for reducing purposes, -- the different separations being made by hand.

The Allis Chalmers mill used in this work is a happy combination of the two. It is large enough to enable the operator to mill similarly to the flow sheets of the large mill, and at the same time small enough to handle accurately a sample of only three pounds with a very negligeable loss in the mill.

If fitted with a middlings purifier, this mill is capable of producing as pure a patent flour as any large mill. However, the size of original sample that would be necessary to make patent flour in sufficient

amount to run a baking test, and the time necessary to produce it, make it impossible to mill in this way if any large volume of work is to be handled.

Accordingly, grain testing laboratories generally have come to the conclusion that for commercial work the production of a straight run flour is the only practical solution. Given, however, a certain sample of wheat, there are innumerable methods of handling the mill to produce flour from it. The products of the different methods will be similar neither in physical nor in baking constants. Therefore it is highly necessary to have some definite system upon which to work.

Entirely aside from methods of manipulating the mill, it is beyond all doubt correct to attempt to produce from the sample on hand a flour that will resemble as closely as possible the flour a large mill will yield from the same wheat. Since we are producing "straight" flour from our experimental mill, we ought therefore to attempt comparison with the straight runs from the big mills.

It is peculiar that at present no large laboratory is doing this. The general method is to compare the experimentally milled flour to patent flour of standard

or supposedly standard qualities. While this idea is capable of furnishing directly comparable figures between several samples, the actual values reported are of little significance unless compared to their proper grade of "straight" flour in terms of the same standard.

Realizing this difficulty, one large laboratory is milling to 45% straight flour in the mill and claims that flour so milled will resemble very closely the patent flour a big mill will produce from the same wheat. It is my opinion that this system is very poor for two reasons. In the first place, comparing a "straight" flour to a "patent" is illogical, and in the second place, various wheats do not yield the same per cent. of patent flour. In milling every sample to 45% straight flour we are not taking into account the variation that will appear in the yield of patent flour, and this is considerable, -- thus throwing in a chance for a very great error.

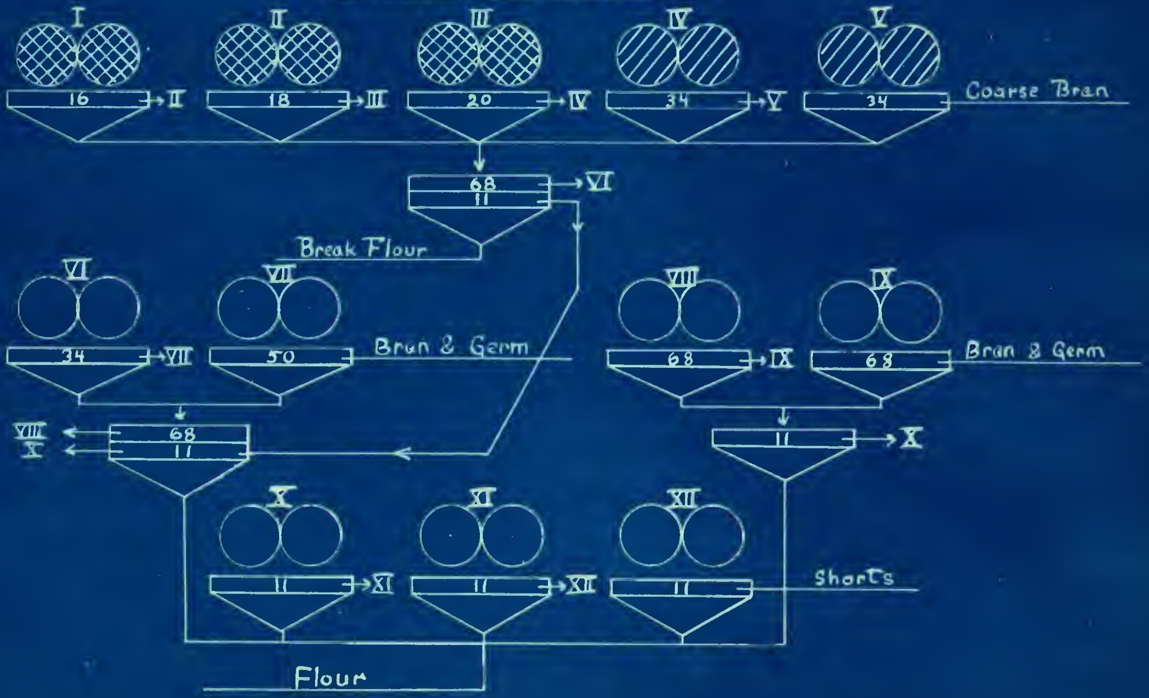
If we can produce only "straight" flour on our experimental mill, we should compare it to straight flour, and the flour we produce should be milled according to a flow sheet resembling as closely as pos-

sible the average flow sheet of the big commercial mills. There is, however, considerable cause for discussion on this point.

A large mill averages somewhat over 70% total flour, of which 5% is usually low enough grade to be thrown out in the process from the straight run. If, then, we attempt to mill to 66% flour, we should get a flour resembling the commercial grade. The difficulty is in selecting a flow sheet for the mill. It is clearly possible for one person to mill close on the bran and the other close on the shorts, and in that way both get the same percentage of flour but with very different properties.

It appears to the writer that the first requirement for a milling sheet is that the 66% of straight flour produced shall be as good a 66% as is capable of being produced from that particular wheat. Therefore it is very difficult to furnish an exact flow sheet that can be followed to the letter, but the operator of the mill should bear in mind that he is to get as good flour as is possible from his sample. It is convenient, however, to have some fairly definite idea as to the flow of the wheat thru the mill; and for that reason the attached sheet is presented. It should be remembered, however,

MILLING SCHEME



that this represents only the skeleton of the system, and that the mill must be adjusted and the flow varied in many cases to suit the requirements of the stock.

This flow sheet will yield about 66% flour, 4% shorts and 30% bran. The Roman numerals indicate the break or reduction number. The rectangle below the rolls represents the sieves that perform the operations of scalping, grading, and dressing. The circles with cross lines in both directions represent the coarse corrugated rolls, while the circles with lines in only one direction represent the fine corrugated rolls. The smooth rolls are represented by open circles. The Arabic numerals refer to the number of wire and bolting cloth used, thus, #16, #18, and #20 are wire cloth, #34, #50, and #68 are bran and shorts sieves, and #11 and #12 are flour sieves. The fineness increases with the higher number, but one must understand that the flour sieves are in a different series from the others.

The first break should have the rolls set in such a way that the berry is just broken open, and the further breaks should be adjusted to roll open the berry rather than to crush it. After the bran is rolled out flat, the rolls are moved in a little more each time so as to

shave off the flour. The adjustments on the smooth roll will depend entirely on the stock and cannot be given in general terms.

The finished flour is run thru a #9 bolting cloth several times to remove any small amount of bran that may have crept into it and to make the sample uniform.

With the above system a very excellent flour can be produced, which, considering the fact that no middlings or other air draught purifier is used, contains a remarkably small amount of specks. The complete milling operation is capable of being run in 50 minutes including the cleaning of the mill to prepare it for the next sample.

It is not claimed by any means that the experimentally made flour will equal in every respect that obtained in practice on the larger scale; but usually the results will be sufficiently near comparative with each other to afford valuable information. The practical miller will naturally make allowances for the milling peculiarities of the wheats he may be thus examining.

If it were only possible to obtain a standard wheat sample the larger part of the difficulties in this re-

spect would be done away with immediately. It would simply be necessary to treat the sample to be tested and the standard sample identically in both mill and bake, and the results would be directly comparative irrespective of flow sheet, kind of flour produced, personal equation, or type of mill. As it seems to be almost completely impossible to obtain a sample of wheat that can be called standard, we must content ourselves with the previously outlined approximate methods.

Tempering The Sample

The main object of tempering wheat before milling is of course to toughen the bran in such a way as to make it flatten out between the rolls rather than break up into very small pieces and thus yield a flour with a high proportion of specks.

There are probably as many methods of tempering wheat as there are mills. I have been told by the superintendent of one mill that at one time he visited three large mills located in the same town. One mill was grinding the wheat as it came from the cars, the second was literally soaking the kernels with cold water, and the third was using live steam. The beauty of it all was that each mill was producing an admittedly high grade flour.

Personal equation probably plays the most important part in the matter of tempering. Each miller knows just how he wants his wheat to enter the first breaks, and any method that will get it into that condition is acceptable. If we take the large average of mills today, we find that warm water alone or cold water in combination with steam is most generally used, but that

the time of application varies from two minutes to fifteen hours.

It has been the practice in this laboratory to use water of about 40° C. in fairly large amount, and to allow it to soak in for about three hours, during which time the jar containing the sample is shaken up and inverted every half hour. With the proper amount of water, this method appears to yield a very tough bran, without affecting the inside of the kernel. The exact amount of water to be used cannot be given in general terms. For hard wheats about 35 c.c. per 1000 grams and for soft wheats about 15 c.c. per 1000 grams was used, but the amount depends more on the conditions of the berry than the variety.

There are laboratories that make a practice of milling without any conditioning of the wheat sample whatever. In the interest of producing as good a flour as possible with the equipment at hand, tempering the sample was found to be an absolute necessity.

The Baking Test

Discussion

With a given milling equipment there is but little possible variation in the method of manipulation if we grind to a certain grade of flour. This cannot be said to be true when it comes to the baking of bread. There are many different kinds of bread, and as many if not more methods of handling the dough before baking. Hence it would not seem a very simple problem to select any one method to be used for average tests, where we are dealing with many different varieties of flour.

However, the results of some tests run during the course of these experiments are so definite that they are included at this point to give foundation for an assertion to be made in the following pages. In explanation of these figures, suffice it to say that they signify a comparison between two different flours, and that each set of figures represents the results of a separate baking test. The important factor is that these three bakes differed as widely in method of handling the dough as possible, but that within each

test the two loaves being compared were handled identically. Each loaf is of course compared to its own standard.

The report follows:-

	Standard	A	B	C
Absorbtion	57.5	58.0	58.0	58.0
Color	100.0	99.0	99.0	99.0
Loaves per bbl.	100.0	100.3	100.3	100.3
Size of Loaf	100.0	95.7	95.8	96.0
Quality of Loaf	100.0	99.0	99.0	98.0
Average Value	100.0	98.5	98.5	98.3
Fermenting Period	100.0	100.0	100.0	100.0
Quality of Gluten	100.0	91.4	91.5	91.7

It is understood that the column labelled "standard" represents in reality three separate loaves, but as the figures will be the same in all cases they are placed in one column. The columns "A" "B" "C" represent three separate bakes of the same flour by different methods. On account of the percentage system these different figures are directly comparable with each other. It will be noticed immediately that the columns are practically identical. This means that the method of baking is not the important factor. It is only that whatever method is used each loaf must receive similar treatment with its standard. Thus the

choice of method will not depend on the type of loaf we wish to obtain, but solely on the commercial adaptability of the method. Under these circumstances we naturally will use that method which will allow us to run the most tests.

Now there are two general types of dough-handling methods adapted to the baking of tinned bread. These are generally known as the "sponge" method and the "straight dough" method.

In the sponge method somewhat less than one half of the flour is mixed with an equal weight of water and all other ingredients. It is then allowed to ferment for 1 1-2 or 2 hours, depending on the type of flour, and is then mixed with the remainder of the flour and water to make a dough of the proper consistency. It is then allowed to rise twice and is formed into loaves, placed in the pan it is to be baked in, and allowed to rise a definite amount. It is then baked. The complete operation takes about 4 1-2 hours.

The straight dough method is in general the same as the sponge method with the omission of the sponging stage. In other words the dough is mixed to the proper consistency for baking at the very start of operations

instead of after a sponging stage. This naturally subtracts the time of sponging from the operation and enables a far larger number of samples to be handled.

In fact, with the same equipment, it has been found that just double the number of samples can be handled in one 8-hour day if the straight dough method is used instead of the sponge method. The quality of the loaves will be uniformly slightly lower, but the results being comparative with each other, this cannot affect the test.

For the above very potent reasons, the straight dough method is used in these experiments.

The Baking Test

Method

A modification of the baking tests as outlined in Bulletin 117 of the Kansas State Agricultural College was used, because several things, as explained later, were thought necessary to bring the test into such form that its results would more closely give the actual commercial value of the flour.

For instance it was found that some flours from the red wheats of the southern states could not be baked satisfactorily by the above original method, whereas they are used to good results in practice. The modification as will follow gives very good loaves.

In making baking tests on different flours it is above all desirable that the test should be so conducted that the differences in the results should be caused by the inherent qualities of the flour and not by variations due to the method employed. However, in practice the skilled baker adapts his method to suit the different flours he uses, and he remedies the defects in the flour to some extent by the method of baking he uses. Therefore it has been the writer's aim to con-

duct these tests in such a way as to get as good bread as possible from the different flours, and if necessary to vary the method of baking in some slight details to be able to do this. That such a method will yield results that more closely approximate the results the flour is going to give in actual use is apparent.

The actual baking and its associated tests were made as follows:-

The Straight Dough Test

In these tests "dough" means a flour mixture that has been subjected to a short period of fermentation and baked as soon as the dough has risen a standard amount. This amount is fixed by preliminary trial and is uniform in all these tests. The short period of fermontation varies from 1 to 3 hours and is secured by using fresh yeast in large quantities.

Before making the dough we must know the percentage of water that the flour will absorb to be of correct stiffness. This is found by weighing out 30 grams of the flour into a strong teacup and running in distilled water from a burette until the resultant dough is "right." The best test that the dough is "right" is to put it on the

bottom of the cup in the form of a round ball and watch it for about 3 minutes. If it gradually settles down until it touches the rim of the circle on the bottom of the cup, it is satisfactory. If it stays in the original shape it is too stiff, whereas if it quickly subsides and overlaps the edge of the cup it is too thin. This test will be found to be sensitive in careful hands to within .25 c.c. on 30 grams of flour. The water that the flour absorbs is figured in percentage.

Now the dough can be made. 340 grams of flour, 10 grams of sugar, and 5 grams of salt are weighed out. The amount of water as determined by the absorbtion test, less 50 c.c., is also measured out. The flour is placed in the pan it is to be baked in and placed in the constant temperature oven until it reaches 35° C. As many grams of yeast as are necessary for the whole batch of loaves are weighed out and dissolved in enough cold water to just be able to draw out 50 c.c. of the resultant solution for each batch of dough. 10 grams of yeast should in this way get into each batch of dough.

When the flour is warmed to the right temperature it is removed from the oven and 2-3 of it is placed in a dish. The water as measured out is heated to 42° C.

and the sugar and salt dissolved in it. Then exactly 50 c.c. of the yeast solution are withdrawn in a pipette and added to the sugar and salt solution. The temperature of the resulting mixture should be very close to 35° C. This liquid mixture is then added to the flour. The resultant batter is beaten up with a large spoon or spatula until there are no more lumps, which usually takes about 2 minutes. The remainder of the flour is then added and the dough mixed, first by means of spatulas and then the hands, to a ball of well kneaded consistency. After this operation, which usually takes but two or three minutes, the dough is placed back in its pan, which has been buttered in the meantime, and put back in the rising oven where it is kept at 35° C. The dough is weighed at this juncture to ascertain the loss during the kneading. This loss is unavoidable, and usually is about 15 grams. It is due mostly to evaporation of moisture and sticking of some flour to the hands.

The dough is now allowed to rise the standard amount and if it is a <u>very</u> weak flour from a soft wheat, it is immediately baked, but if the flour has any reasonable strength it is knocked down, rekneaded, and allowed to

rise a second time, and at the termination of this rise if the dough of one of the loaves shows signs of collapsing that loaf is then baked, otherwise a third rise is used. Most flours coming from sound wheats will stand three rises; they will even need them. The times of rising are carefully noted, and all loaves are baked exactly 30 minutes at 238° C. About 1-2 to 3-4 of an hour after the loaf has been standing in the open air, it is weighed, and this weight is recorded as the weight of the hot loaf. This must of course be corrected for the small amount of dough lost in the kneading.

In measuring the volume of the loaf it is put in an oblong box that already contains some turnip seed. Then the box is filled with the seed, gently rapped, and the seed leveled off at the top. The seed is poured out and weighed, and from the weight of seed that the box will contain when there is nothing but seed in it, the volume of the loaf can be obtained, since the volume of the box is known. This method has been found to be accurate to within 5 grams weight of seed, which corresponds to about 2-5 cu. in. in volume.

The volume should be measured approximately one hour after removing the loaf from the oven as it will shrink

more and more the longer it stands.

Gluten Expansion Dough Test

This is for the purpose of testing the quality of the gluten and checking the relative fermentation period of the flour. The proceedure is identical as for the straight dough except that 100 grams of flour are used instead of 340 grams, and the other ingredients in proportionate amounts. At the point where the regular dough would be panned, this dough is placed in the bottom of a well greased glass cylinder which is at a temperature of 35° C. and placed in the rising oven at 35° C.

For the first hour no attention is required, but after that the height of the dough and the time should be recorded every 15 minutes; and later when it is evident the dough is near its maximum volume, every five minutes. When the dough just begins to fall the volume and time are noted. From the difference in initial and final volumes the relative qualities of the glutens are calculated. Since we start with the same amount of flour, the quality of the gluten itself will be equal to the net rise divided by the per cent, gluten in the

sample. This figure is then referred to the similar figure of the standard flour on a percentage basis.

Another method of performing this test which seems to yield more definite results uses the gluten itself instead of the dough. For this purpose the gluten is washed out of the flour in the usual way, and then 10 grams of each gluten is placed, wet, in a tin cylinder 1 inch in diameter and placed in the bake oven at 200° C. It will be found that the gluten will expand and after twenty-five minutes will have formed a porous column within the tin. The height of this column will be directly proportional to the quality of the gluten.

In making all these tests, a flour the baking qualities of which are known, is selected and tested at the same time as the other flour. The results are compared on a percentage basis and in this way the unknown flour is judged.

The usual form of report sheet is attached. The "gluten" and "ash" are the results of chemical tests, the "absorbtion" is reported in per cent. and is obtained as previously explained. "Color," "Loaves per bbl.," "Size of Loaf" and "Quality" will represent, on a basis

of Standard = 100%, those values for the tested sample. The "Average Value" as stated is the mean value of the above four. "Fermentation Period" is calculated from the total time necessary for rising, and "Quality of Gluten" is obtained as explained previously.

A report of this kind, when the miller knows your system of milling and your standard, will tell him exactly what the wheat or flour under discussion is worth to him.

Reasons for Disagreement in Results

It was found possible by following the above methods very carefully to test samples of the same flour within the following limits:-

Volume of Loaf	1.2 cu. in.
Weight of Loaf	7 grams
Texture of Loaf	no variation
Color of Loaf	no variation
Quality of Gluten	5 c.c. in 450 c.c.
Fermentation Period	12 min. in 190 min.

With the above very satisfactory results in my own work it was again attempted to check the other commercial laboratories. Three samples of #2 Hard Winter wheat were sent to laboratory "B" and their report compared with my own work according to the method I have just outlined. The reports are unique in the fact that they show absolutely no similarity whatever in either chemical or milling and baking results. The data is given in the table.

For instance "B" grades #3 best of all while I graded #2 the best; also there is in most cases over one per cent. difference in protein results; while the ashes are too far apart to be considered at all. The variation in the chemical work has been previously

		Sample 1		Sample 2		Sample 3	
	Standard	Lab. "B"	Home	Lab. "B"	Home	Lab. "B"	Home
Gluten	9.5	9.6	10.9	9.3	10.9	8.1	9.0
Ash	.35	.43	.39	.42	.37	.40	.41
Absorbtion	57.0	58.0	57.5	58.0	57.5	58.0	57.5
Color	100.0	93.0	100.0	93.0	100.0	95.0	100.0
Loaves per bbl.	100.0	100.6	100.0	100.6	100.0	100.6	100.0
Size of Loaf	100.0	100.0	103.5	100.0	107.0	100.0	103.5
Quality of Loaf	100.0	98.3	102	98.5	102	98.5	102
Average Value	100.0	98.0	101.4	98.0	102.2	98.5	101.4
Fermenting Period	100.0	100.5	116.1	99.0	116.1	93.6	116.1
Quality of Gluten	100.0	99.5	102	101.0	106	107.3	102
% Straight Flour Milled		68	64.8	67	65	67	65.8

cleared up in my favor, but it is hardly credible that a laboratory with a good reputation would lay itself open to losing it by consistently careless work.

I am inclined to think rather that the lack of agreement, in the baking tests at least, is due to the following facts:-

(a) Different methods of milling will seriously affect the result.

(b) The use of old or new yeast will affect the relative volumes of the loaves decidedly, this being a point especially liable to give trouble as weak and strong flours are by no means equally affected by the same variations in the yeast.

(c) The fact that "B", for one, always reports 100% for the volume no matter what the variety of wheat shows that instead of baking each flour for its best result as it will be handled in practice, he is baking to constant volume or nearly so, and this alone would throw off all chances of comparison.

(d) Different stiffnesses of dough used will vary the volume of the loaf.

(e) Different laboratories are using different standards.

Several of the above statements need explanation.

To show very clearly the difference in the method of milling, several wheats were milled light to 45% flour and the same wheats also milled according to the regular process to 65% flour. These four samples were baked side by side, and in the case of the soft flours a difference of 6 cu. in. in volume was obtained, while the strong flours yielded a difference of 2.5 cu. in., all in favor of the lighter milled samples. The color and texture of the loaves baked from the 45% flour also were at least 2% better than those values for the 65% flour.

Also several samples were baked using old and new yeast, other conditions being the same. A record of this bake follows:-

	Spring Flour	Winter Flour
Weight of Yeast Used	10 grams	10 grams
Weight of Flour Used	340 grams	340 grams
Weight of Water Used	190 grams	175 grams
Weight of Sugar Used	10 grams	10 grams
Weight of Salt Used	5 grams	5 grams

Volume of Loaf

Fresh Yeast	83.7	85.0
Two Days Old Yeast	85.0	82.2
Three Days Old Yeast	82.4	80.2

Relative Volume of Loaf from Soft Flour

Fresh Yeast	101.4%
Two Days Old Yeast	96.7%
Three Days Old Yeast	97.3%

The much more decided effect of the old yeast on the weaker flour is very evident.

To show clearly the effect of too much or too little water in the dough a test on two sets of flours was run, using extremes of water. The flours used were milled from a spring wheat and a winter wheat respectively. The data of the test follows:-

	Spring		Winter			
Water Used	191	181	186	166	176	176
Volume	83.8	78.0	82.0	69.8	77.2	77.6
Color	100	100	99	99	99	99
Texture	100	100	98	96	98	98

It is clearly seen that working a dough too stiff cuts down decidedly on the volume of the loaf, but that a reasonable overdose of water has no detrimental effect, but rather a good one. It is very unlikely that too much water will be used in any case, as the kneader will immediately become aware of the fact by the stickiness of the dough. But it is quite possible not to have enough water, and not to notice the fact.

Summary

In the foregoing pages I have tried to show the importance of this line of chemical work, and at the same time indicate the unsettled condition of affairs. It is very evident that if the different commercial laboratories do not choose some one system of working, and follow this system out conscientiously, very little comparative value can attach itself to their reports.

It certainly is deplorable that at present it is impossible to get even a similarity between reports from different laboratories on the same wheat or flour sample.

In view of the past discussion, it seems to me that to remedy this all laboratories in this line should mill their wheat and bake their flour according to some definite and uniform plan. Such a plan, very representative of conditions in the big mills, has been suggested. The baking method should be such that it brings out the commercial value of the flour and not the comparison produced by subjecting the flour to abnormal conditions. The test as suggested does this very nicely.

Then to get the same results it will be necessary only to adhere strictly to six rules, which can be shortly and simply stated as follows:-

(1) All wheats should be milled to a definite percentage of flour (66%) according to a uniform milling sheet, so that one person does not mill close on the bran and the other close on the shorts and in that way both get the same percentage of flour, but quite different in properties.

(2) The yeast used in the experiments should be controlled not by taste or feel but by actual "gas" tests so as to eliminate all chance of the yeast affecting the results by having one laboratory use old yeast and another fresh, strong yeast, in that way rendering a comparison of their reports an impossibility.

(3) Loaves should be baked for their own particular merits, and not according to conditions that they will be sure not to meet in commercial baking.

(4) The amount of rise in the expansion case before baking should be controlled very carefully, and all should allow the same rise. I have found by repeated tests that three minutes overtime on the last rise will affect the volume of the loaf as much as 10%, and

if the dough is allowed to rise too far or too short on one of the preliminary rises the volume will not be so affected but the texture will.

(5) In order to do away with all chance of personal equation, it would be best for all to use mechanical kneading machines. This would eliminate all possibility of trouble from this source, but it is very doubtful to the writer whether any variation in the results really exists here.

(6) All should use the same standard flour. To be sure of no trouble, arrangements should be made so that every laboratory gets its standard flour from the same batch of one mill.

It is the writer's opinion that if the methods of milling and baking as suggested in this paper and the precautions as just suggested in the six preceding rules are conscientiously taken, the greater part of the trouble arising from commercial laboratories in this line of work not checking will be overcome, and that a very difficult point in the grain analyst's duties will be cleared up.